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RADIO TELEMETRY DOCUMENTS 24-HOUR FEEDING ACTIVITY OF WINTERING LESSER SCAUP

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Abstract.—We used radio telemetry to record 198 h of feeding behavior of five Lesser Scaup (*Aythya affinis*) on the Indiana Harbor Canal in northwestern Indiana during January and February 1994. Lesser Scaup fed for short periods of time intermittently during each 24-h period. Lesser Scaup fed a total of 96 min during the day and 226 min during the night. They fed more between sunset and midnight (31.9% of the period, $P = 0.003$) than between sunrise and noon (11.6%) or noon and sunset (19.5%); time spent feeding between midnight and sunrise (26.3%) did not differ from other times of day. Mean dive duration (22.9 ± 0.64 sec) did not vary by time of day ($P = 0.186$–0.744). These results are the first 24-h feeding activity reported for individually marked Lesser Scaup. *Received 27 Sept. 1995, accepted 3 Feb. 1996.*

Knowledge of both diurnal and nocturnal activity is needed to understand the use of time and energy by waterfowl (Jorde and Owen 1988). However, estimates of 24-h activity of waterfowl, especially diving ducks, generally are difficult to obtain and often are imprecise. Night-vision light intensifiers (NVLI) have been used to document nocturnal activity based on scan census or focal animal observations (Tamsier 1976, Jorde et al. 1983, Paulus 1984, Takekawa 1987, Bergan et al. 1989). Night observations, however, are often limited by access and viewing area (Jorde and Owen 1988, Bergan et al. 1989). Scan counts underestimate feeding activity for diving ducks, because some birds are underwater during the scan (Siegfried 1974). Also, studies of diving ducks using focal animal methods are impossible to conduct in many situations because it is difficult to keep track of individual birds in large flocks (C. Custer, pers. obs.).

Few studies have recorded 24-h activity budgets of Lesser Scaup (*Aythya affinis*). Wintering male Lesser Scaup in South Carolina spent <10% of their time feeding at night and approximately 40% of the day feeding (Bergan et al. 1989); data were collected using focal-animal sampling (5-min duration/bird) and NVLI. In contrast, wintering Lesser Scaup on the Mississippi River in Wisconsin spent 28% of the night feeding and 16% of the day; data were collected using modified scan sampling and NVLI (Takekawa 1987). We are aware of only one study that quantified 24-h activity budgets of individual waterfowl. The activities of a single breeding male European Pochard (*Aythya ferina*) were recorded through-

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out one 24-h period with the aid of a field glass of high luminosity on a bright moonlight night (Klíma 1966).

The attenuation of radio signal strength has been used with penguins to quantify timing and duration of feeding behavior (Trivelpiece et al. 1986). Radio telemetry has not been used to quantify feeding of diving ducks, however. Our objective was to quantify 24-h feeding activity of Lesser Scaup wintering on the Indiana Harbor Canal (IHC) (41°38′N 87°28′W) using radio telemetry.

STUDY AREA AND METHODS

The IHC and Grand Calumet River system (Fig. 1) contains some of the last remaining wildlife habitat within the urban, industrial corridor that dominates the south shore of Lake Michigan (Brock 1986). Only 50 of 10,000 acres of inland beach-ridge dune and swale habitat still remain (Bacone 1979), and these wetlands along with the Grand Calumet River and IHC provide resting, feeding, and loafing habitat for migrating and wintering birds (Brock 1986), and breeding habitat for Black-crowned Night-Herons (*Nycticorax nycticorax*), Barn Swallows (*Hirundo rustica*), Herring Gulls (*Larus argentatus*), and Mallards (*Anas platyrhynchos*). During winter, the IHC is routinely used by 200–300 Lesser Scaup (J. Simesko, Lake Dock Co., pers. comm.; Custer et al. 1996). Indiana Harbor Canal was constructed in the early 1900s for navigation and to carry waste discharges from 30 outlets to Lake Michigan (Bolts 1993). The physical structure of IHC, $<$50-m wide, open water, and unlimited access to some observation sites enabled us to monitor 24-h activity budgets. From the trap site out to Lake Michigan, IHC has straight-sided concrete/steel walls and is $>$3m deep with no rooted, submergent vegetation. South of the trap site, soil banks predominate. The banks slope gradually into the water which becomes shallower ($<$1.5 m deep) and supports some aquatic vegetation.

We implanted radio transmitters (164–167 Mhz) in the abdominal cavity (N = 10) or subcutaneously (N = 2) in 12 male Lesser Scaup trapped in a baited, swim-in corral trap (Haramis et al. 1987) in IHC (Fig. 1). We stopped trapping after our scaup were radio marked. Abdominal implants, procured from Advanced Telemetry Systems Inc., were cylindrical (50-mm long, 20-mm diameter) with an internal, coiled antenna and weighed about 20 g. Subcutaneous implants, Holohil Systems Ltd., were disc-shaped (20-mm diameter, 8-mm thick) and implanted in the upper back with an external flexible antenna and weighed about 5 g. The heaviest transmitter weighed $\leq$3% of the duck's body weight. We implanted all transmitters within 5 h starting at 20:00 CST, 6 January 1994, and released the scaup at the trap site at 10:00, 7 January. The transmitters were implanted under sterile conditions; scaup were anesthetized with isoflurane, the transmitter implanted, and the duck immediately revived with 100% oxygen (Olsen et al. 1992, Korschgen, pers. comm.). We followed approved Animal Care and Use protocols of Northern Prairie Science Center, Jamestown, North Dakota. We assumed that the Lesser Scaup we trapped were representative of the flock present in IHC during this study.

Before establishing data collection protocols, we observed general feeding patterns of Lesser Scaup for several hours. We found that Lesser Scaup fed while diving in one area or while slowly swimming, dived and surfaced in a consistent pattern of underwater and surface times, and did not interrupt feeding with preening, bathing, resting, or other behaviors. Feeding individuals were usually $\geq$10 m from roosting and resting flocks of Lesser Scaup and rejoined these flocks after feeding.

We used changes in radio signal strength to determine when a radio-marked Lesser Scaup

FIG. 1. The Grand Calumet River–Indiana Harbor Canal study area, East Chicago, Indiana, showing the trap site and behavioral observation sites, January–February, 1994.

was feeding, i.e., no signal or a weak signal was received when the duck was under water (Trivelpiece et al. 1986). Visual observations of a radio-marked Lesser Scaup confirmed that dives inferred by signal strength were actually dives.

To select an appropriate observation interval to monitor feeding behavior, we listened to signals from three feeding Lesser Scaup continually for ≥30 min each and another radio-marked scaup for 5 h. Bouts of feeding (N = 15) lasted 11.1 ± 1.39 min (± 1 SE); therefore, we selected 10 min intervals as the minimum needed to detect feeding behavior.

We established behavioral observation sites at four of 15 locations (Fig. 1) because we had 24-h access to these four sites. Additionally, these sites were where many of the radio-marked scaup spent the winter (Custer et al. 1996). On days that we recorded behavior, we checked each site until we located one or more radio-marked Lesser Scaup. There were usually ≤3 radio-marked Lesser Scaup at a site. We collected behavioral data on the radio-marked scaup using two methods: 10-min scans and focal-animal sampling (Altmann 1974). We collected 10-min scan data to estimate percent of time spent foraging. We listened to each radio signal for 2 min at 10-min intervals and determined whether the duck was feeding (diving) or not feeding. The rhythmic pattern of ducks diving to feed allowed us to differentiate feeding activity from random changes in signal strength or temporary loss of signal (Kenward 1987:130). Secondly, we used focal animal sampling to quantify the duration of foraging dives. Between 10-min scans, we selected a feeding duck and recorded for 3–6 min the time it spent above and below the water's surface while feeding. When more than one scaup was feeding, we alternated focal animal observations equally among the scaup present.

Behavior was recorded by human observers or by video taping the radio receiver. During video recordings, we programmed the radio receiver to scan 4–5 frequencies sequentially for 2 min each. A camcorder was focused on the radio receiver's display and thus recorded both the monitored frequency and the audio speaker sounds. The camcorder also recorded the time of day. Only observations of radio-marked birds whose behaviors were recorded continuously for ≥4 h (N = 5 scaup) were included in the analyses. The other seven radio-marked scaup were located only infrequently or in areas where we could not record continuous behavioral observations.

We recorded behavior during four periods: morning (sunrise to 12:00 h CST), afternoon (12:01 h to sunset), evening (sunset to 24:00 h), and night (00:01 h to sunrise). Duration of time periods ranged from 5 h–5 h 20 min for daylight periods and 6 h 20 min–6 h 40 min during evenings and nights.

For each scaup, we calculated the frequency of consecutive 10-min scans during which it was feeding and not feeding during each time period. We analyzed frequency data by time period and by duck with Fisher's Exact Tests (Zar 1984). Categories for number of consecutive 10-min scans during which an individual was feeding were 1, 2, and 3+. Three or more consecutive scans were combined into one category for frequency analyses to reduce the number of cells with zeros. When the overall Fisher's Exact Test was significant, all pairwise combinations were tested to determine which frequencies differed. An alpha of 0.005 was used for pairwise Fisher's Exact Test comparisons to give an overall $P < 0.05$ (Neter et al. 1985). We pooled 1 and 2, 3 and 4, 5 and 6, and 7+ consecutive 10-min scans without feeding for statistical tests to reduce the number of cells with zeros.

Percent of time spent feeding during each time period by each duck was calculated from the 10-min scan data (Altmann 1974). A fixed-effect, 2-way analysis of variance (ANOVA) model was used to compare the average percent of time spent feeding among ducks and time periods. We used Bartlett's test to test the homogeneity of variance assumption of ANOVA (Zar 1984:181). When variances were not homogeneous, percents were square-root arcsine transformed. Untransformed percents ±1 SE are presented in text and tables.

Repeated measures statistics were not possible with these data; therefore, all data were analyzed and presented by individual duck to account for individual variation. We used an alpha of 0.05 for all ANOVAs.

We used one-way ANOVA to test our null hypothesis that average time (sec) spent underwater per dive searching for and retrieving food did not differ among time periods or among ducks. Empty cells precluded using 2-way ANOVA. Because there were no time differences, we combined all time periods and tested for differences among individuals.

RESULTS

We recorded 198 h of behavior on five radio-marked Lesser Scaup between 27 January and 16 February 1994 in IHC. Weather patterns during the study were normal; daily maximum temperatures were between −10° and 0°C with occasional snowfall. The normal high temperature for February is −2°C (Bair 1992).

Lesser Scaup fed intermittently for short periods throughout the 24-h period (Fig. 2). As an example, Lesser Scaup #4566 fed during nine 10-min scan periods between sunset and midnight on 2 February; the first feeding bout lasted for two consecutive 10-min scans (Fig. 2). The modal number of consecutive 10-min scans during which Lesser Scaup were feeding was one for four of five Lesser Scaup (Table 1). Lesser Scaup #4666 differed from the other four scaup (pairwise Fisher's Exact Test, all Ps ≤ 0.002) with a mode of 3+ consecutive 10-min scans with feeding (Table 1). The median number of consecutive feeding bouts for all scaup combined was one. Frequency of consecutive 10-min scans with feeding did not vary by time period (3 × 4 Fisher's Exact Test, $P = 0.716$, N = 98); feeding bouts were not longer or shorter during any particular time period.

The number of consecutive 10-min scans without feeding did not differ among ducks (Table 1) or among time periods (4 × 4 Fisher's Exact Test $P = 0.318$, N = 98). The median number of consecutive scans without feeding was four for all scaup and time periods combined.

Lesser Scaup fed for 23.7 ± 2.5% (SE) of each 24-h day. They spent a greater proportion of their time feeding during the evening period (31.9 ± 5.07%, N = 16 evening periods) than during the morning (11.6 ± 2.60%, N = 9) or afternoon periods (19.5 ± 4.62%, N = 13). Proportion of time spent feeding during the night (26.3 ± 4.16%, N = 13) did not differ from the other three time periods ($F = 5.75$; df = 3,33; $P = 0.003$). The time spent feeding varied among individuals (Table 2), but there was no interaction between time period and individual duck ($F = 0.89$; df = 10,33; $P = 0.548$).

Time spent underwater per dive to search for and retrieve food did not differ among the four time periods (22.9 ± 0.64 sec, N = 57; Ps 0.186

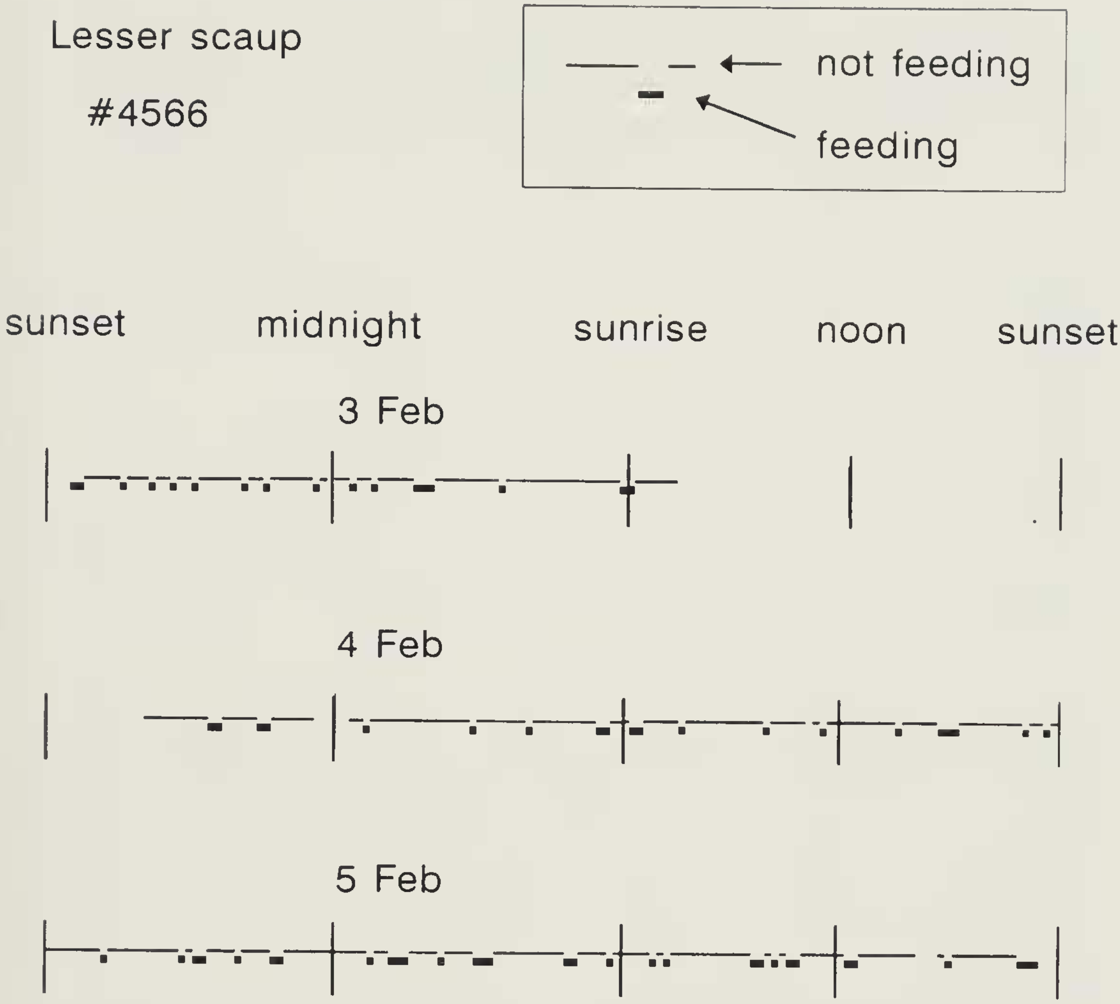

FIG. 2. Summary of 40+ consecutive hours of 10-min behavior scans for Lesser Scaup #4566 in Indiana Harbor Canal, East Chicago, Indiana, 2–5 February 1994.

− 0.744). Bird #4566 spent significantly less time underwater than bird #4616 or bird #4666 (Table 2), however.

DISCUSSION

Our study further demonstrates the need to collect nocturnal data to better understand the feeding ecology of Lesser Scaup. On some wintering areas, feeding is more prevalent at night than during the day (Takekawa 1987 and this study). The proportion of time spent feeding during nocturnal hours (29%) and diurnal hours (16%) in IHC was strikingly similar to that of Lesser Scaup on the Mississippi River in Wisconsin which spent 28% of the night feeding and 16% of the day (Takekawa 1987). Tufted ducks (*Aythya fuligula*) in Switzerland, a closely related species, also spent a higher proportion of the night feeding (30–50% of the night) than they did during the day (<10% of the day) (Pedroli 1982). In contrast,

TABLE 1

NUMBER OF CONSECUTIVE 10-MIN SCANS DURING WHICH RADIO-MARKED LESSER SCAUP WERE FEEDING AND NOT FEEDING IN INDIANA HARBOR CANAL, EAST CHICAGO, INDIANA, JANUARY–FEBRUARY 1994

Transmitter frequency	Consecutive 10-min scans								
	Feeding				Not feeding				
	1	2	3+		1–2	3–4	5–6	7+	
4566	32	17	4	A[a]	10	8	10	19	A[b]
4616	7	2	2	AB	5	2	1	4	A
7029	8	1	0	AB	2	1	1	2	A
4637	7	0	5	B	4	3	0	3	A
4666	0	5	8	C	4	4	1	2	A

[a] Frequency distributions sharing same letter are not different among Lesser Scaup, 3 × 5 Fisher's Exact Test ($P < 0.001$). Pairwise comparisons to separate individual Lesser Scaup were considered significant at $P < 0.005$ for an experiment-wide alpha level of $P \leq 0.05$.
[b] 4 × 5 Fisher's Exact Test ($P = 0.699$).

male Lesser Scaup in South Carolina fed <10% of the night and approximately 40% of the day (Bergan et al. 1989). Human disturbance is often cited as the reason for nocturnal feeding (McNeil et al. 1992). Our study and the study in South Carolina, however, were conducted in areas with little human disturbance; therefore, this would not explain the difference between the two studies. Neither cold temperatures (down to −10°C) nor precipitation affected percent of time spent feeding (Cronan 1957, Noseworthy 1981, Takekawa 1987), so temperature should not be a factor when comparing these two studies.

Although the percent of time spent feeding during day and night in the

TABLE 2

AVERAGE TIME SPENT FEEDING AND TIME SPENT UNDERWATER PER DIVE BY RADIO-MARKED LESSER SCAUP IN INDIANA HARBOR CANAL, EAST CHICAGO, INDIANA DURING JANUARY AND FEBRUARY 1994

Transmitter number	Time feeding (%)				Time underwater (sec)			
	Mean		SE	N[a]	Mean		SE	N[a]
4666	39.2	A[b]	6.67	11	25.0	A[c]	0.82	24
4637	36.7	AC	7.04	6	22.9	AB	1.41	8
4566	17.5	BC	1.86	20	19.4	B	0.92	20
4616	17.4	B	4.69	10	26.3	A	2.43	5
7029	9.0	BC	2.12	4			.	

[a] N = number of time-of-day periods for which percent of time spent feeding or time underwater was calculated.
[b] Means sharing same letter are not different ($F = 5.60$; df = 4,33; $P = 0.002$).
[c] Means sharing same letter are not different ($F = 7.90$; df = 3,53; $P < 0.001$).

IHC was different from some other studies, the total amount of time spent feeding (5.7 h/d) in IHC was similar to Lesser Scaup in South Carolina (4 h/d) (Bergan et al. 1989), Lesser Scaup on the Mississippi River (4.1 h/d) (Takekawa 1987), and Tufted Ducks in Switzerland (4.8–5.2 h/d) (Pedroli 1982).

Lesser Scaup feed for short periods of time (median number of consecutive scans with feeding was one) followed by longer non-feeding periods (median number of consecutive non-feeding scans was 4). The average length of a feeding bout was 11.1 min. We had the longest continuous record on scaup #4566, which demonstrated this intermittent feeding pattern continually for two days. The feeding patterns of the other four Lesser Scaup, although less extensive, were consistent with the pattern of #4566.

During the pre-breeding season (May) in Manitoba, Lesser Scaup repeated a foraging, bathing/preening, resting/sleeping cycle about every 3 h during daylight hours (Siegfried 1974), which was longer than the approximately 1-h cycle we found in IHC during winter. European Pochards in the Bohemian highlands also had a 3–4 h activity which was repeated regularly during a 24-h period during spring (Klíma 1966). Klíma (1966) hypothesized that the open water habitat with its lack of microhabitat variation, minimal human disturbance, lack of phototaxis in prey behavior, and tactile feeding by European Pochards contributed to the similarity of diurnal and nocturnal feeding patterns. Several characteristics of IHC are similar to that of Bohemia; IHC is a relatively undisturbed location without hunting and has little recreational or public use. The scaup seem to have habituated to the industrialized setting, and the bright lights mimic moon-lit nights which are conducive to nocturnal feeding (Adair 1990: 73). Most of the IHC is deep (>3 m) open water, and availability of benthic prey, mainly oligochaete worms (T. W. Custer, Natl. Biol. Serv., unpubl. data), does not vary by time of day (R. Whitman, pers. comm.). Duration of feeding cycles may be a function of the type of prey consumed and the time needed to handle, process, and digest it. Oligochaetes are easy to capture, are very soft, and should be processed through the digestive system more quickly than other more traditional Lesser Scaup food items such as molluscs and arthropods (Swanson and Bartonek 1970, Afton et al. 1991, Custer and Custer 1996).

Time spent underwater per dive ($\bar{x}$ = 23 sec) by Lesser Scaup in our study was similar to that of Lesser Scaup wintering in Chesapeake Bay ($\bar{x}$ = 23.6 sec, G. M. Haramis, Natl. Biol. Ser., pers. comm.) and by Lesser and Greater scaup wintering in Connecticut ($\bar{x}$ = 20.4 sec) (Cronan 1957). However, shorter dive times have been reported for Lesser Scaup in Manitoba during spring ($\bar{x}$ = 10 sec) (Siegfried 1974, 1976); Lesser and Greater Scaup in the Detroit River ($\bar{x}$ = 16.4 sec) (Noseworthy 1981); and Lesser Scaup in South Carolina ($\bar{x}$ = 16.6 sec) (Alexander and Hair 1977). Time spent underwater is not related to water depth (Siegfried 1974) but may be a function of type and abundance of prey being exploited (Noseworthy 1981). Dive time may also be a function of individual behavior that affects distance covered per foot stroke, i.e. diving efficiency (Lovvorn et al. 1991). We do not believe that Lesser Scaup used visual cues to find food in IHC because they feed extensively at night and because of the similarity in time spent underwater searching and capturing prey during the day and night.

We feel that the behavior of these five individuals was representative of the approximately 200 Lesser Scaup (Custer et al. 1996) that wintered in IHC. Food was plentiful (>400,000 oligochaetes/m^2) in the area where we made out behavior observations (U.S. Fish and Wildlife Service-Battelle 1993), and we did not observe overt aggressive behavior (CMC, pers. obs.) that might indicate an abnormal situation. Scaup did not defend foraging sites during winter in South Carolina (Alexander and Hair 1977) and aggressive interactions were uncommon (Alexander and Hair 1977, Bergan et al. 1989).

Radio telemetry is an effective technique to monitor feeding behavior in diving ducks. We were able to recognize individual ducks and use a video recorder to acquire data remotely, an important consideration when continuous 24-h data are needed and availability of personnel is limited. Radio telemetry overcomes (1) the limitations of night-vision light intensifiers (Bergan et al. 1989) and collecting data during inclement weather and other conditions of poor visibility, (2) the problem of locating birds during scan counts (Siegfried 1974), and (3) of keeping track of individuals in large flocks during focal animal observations.

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